REMARKS:

The preceding claim amendments and the following remarks are submitted as a full and complete response to the Office Action issued on February 1, 2010. Claim 1 has been amended to recite that the substrate is made of Si. No new matter has been added. Claims 1, 2, 4-7, 10 and 13 are currently pending. Reconsideration of all outstanding rejections is respectfully requested.

Claim Rejections Under 35 U.S.C. §103

I. The Patent Office has maintained the previous rejection of claims 1, 4, 6 and 10 under 35 U.S.C. §103(a) as obvious over Tian in view of Boyle. Regarding claims 1 and 10, the Patent Office alleges that while Tian does not disclose the substrates recited in these claims, Boyle discloses nanophase ZnO grown on a sapphire substrate and thus "it would have been obvious to choose sapphire substrate for growing ZnO nanorod arrays from a finite number of identified substrates (it would have been obvious to try the specific substrate to grow ZnO nanorod arrays and obtain the predictable result)." With respect to the amended feature of "consisting of," the Patent Office alleges that even though the nutrient solution of Tian further comprises sodium citrate, eliminating a non-essential element is *prima facie* obvious. Applicants respectfully traverse this rejection.

At the outset, Applicants note that claim 1 has been amended to recite that the substrate is made of Si.

Tian discloses synthesis of unusually extended and oriented helical nanostructures in synthetic ceramics. *See* the Declaration by Dr. Jin-Ho Choy ("Choy Declaration"), at Section 6 (citing page 12954, left column, lines 7-8 and 25-

27 of Tian). More particularly, Tian describes making oriented ZnO nanorods and using them as the base material to grow the helical structures. *Id.* The nutrient solution used in Tian to grow the helical ZnO nanostructures contains hexamethylenetetramine ("HMT") (0.10M), sodium citrate (0.0010M) and Zn nitrate (0.030M). *Id.*

As noted in the Choy Declaration, the nutrient solution recited in claim 1 differs from that disclosed in Tian in that it does not contain sodium citrate. *See* the Choy Declaration, at Section 7. However, the Patent Office disregards this difference in determining the patentability of claim 1, alleging that sodium citrate is a non-essential element to a nutrient solution for growing ZnO nanorods. Applicants respectfully disagree with such an allegation regarding the role of sodium citrate because sodium citrate has been used in various preparation methods for ZnO nanorods with the understanding that it is an essential for the optimum growth of ZnO nanorods. In fact, Tian itself explains the criticality of citrate ions as follows:

> Large arrays of oriented helical ZnO nanorods and columns are formed using simple citrate ions to control the growth behavior of the crystal. ZnO by itself tends to grow into rodlike structures along the <001>orientation like calcite, but citrate ions specifically adsorb to the (002) surface and force the crystal to grow into plates. . . In our study, ZnO tends to grow long rod structures without the citrate ions. Results in the literature as well as from our own calculations suggest that citrate ions strongly bind to the Zn atoms on the (002) surfaces. We have shown that the citrate ion binding has a strong inhibiting effect on the growth of (002) surfaces. With citrate ions fat hexagonal ZnO crystals, rather than long hexagonal rods, are produced. A higher citrate concentration leads to the formation of fine ZnO nanoplates.

Tian, page 12954, left column, lines 9-13 and page 12955, right column, lines 22-29.

Therefore, Applicants respectfully submit that contrary to the Patent Office's allegation, sodium citrate is an essential component for the nutrient solution for preparing ZnO nanorods as acknowledged in Tian. Nonetheless, as explained

below, the claimed method provides unexpected and superior results of growing perfectly oriented ZnO nanorods without using the sodium citrate. It has been well recognized that omission of an element ***with retention of the element's function*** is an *indicia* of unobviousness. MPEP 2144.04 (emphasis added). In the present case, the claimed method even produces better results than the method of Tian without using sodium citrate that was recognized as essential for the optimum growth of ZnO nanorods by Tian.

Boyle does not cure the deficiency of Tian. First, Boyle fails to teach or suggest Si as a substrate. Other than a mere assertion, the Patent Office has failed to show that one skilled in the art would have been motivated to replace sapphire with Si with a reasonable expectation of success of obtaining the same results as obtained by claim 1. Thus, absent any additional evidence, Tian, either alone or in combination with Boyle, fails to teach or suggest all the elements of claim 1. Second, while Boyle uses the nutrient solution that does not contain sodium citrate, it discloses using chloride ions as an essential component. As noted in the Choy Declaration, the procedure disclosed in Boyle involves (1) formation of a CBD ZnO template layer of the desired morphology (obtained via judicious choice of ligand and counter-ion) and (2) subsequent growth of acicular rods on the templates. *See* the Choy Declaration, at Section 8 (citing page 80, left column, lines 4 from the bottom to right column, line 2 of Boyle). According to Boyle, "control of the density of the ZnO rod arrays is achieved through the first step while dimensionality and crystallinity are tailored via the second step." *Id.* Boyle further states that ***the rationale behind the second step derives from the need to impede the propensity of ZnO crystallites to undergo basal twinning and to enhance the crystallinity and***

growth of ZnO rods. *Id. (citing* page 80, right column, lines 17-23 of Boyle)(emphasis added). Boyle finally observes that "the best results were obtained for heated aqueous solutions containing zinc acetate, HMT and ***additional chloride ion (the latter appears to impede twinning.***)" *Id.* (emphasis added). Therefore, given these teachings of Boyle, one skilled in the art would have understood that chloride ions are essential to the nutrient solution used in the method of Boyle. No other teaching or suggestion is provided by Boyle, which would have motivated one skilled in the art to omit chloride ions with a reasonable expectation of success of obtaining the results at least equivalent to using chloride ions. Therefore, Tian, either alone or in combination, fails to establish a *prima facie* case of obviousness. Thus, Applicants respectfully submit that the absence of citrate and chloride ions in the nutrient solution of claim 1 should be sufficient to find the patentability of claim 1.

Even if there were any inference of obviousness of claim 1, which there is not, it can be effectively rebutted by the unexpected and superior results that are verified by the Choy Declaration. The Choy Declaration notes that the specification and the drawings of the Present Application demonstrate that the method of claim 1 using such nutrient solution can produce a perfectly oriented ZnO nanorod array. *See* the Choy Declaration, at Section 7. The Choy Declaration explains that Fig. 3 of the Present Application is a powder X-ray diffraction pattern of a ZnO nanorod array formed on a Si-wafer using a nutrient solution containing 0.1M Zn nitrate solution and 0.1M HMT without containing sodium citrate. *Id.* It also confirms that Fig. 3 shows the [00*l*] peaks only without any of the [*hk*0] peaks. *Id.* With these observations, the Choy Declaration opines that Fig. 3 clearly evidences the ZnO nanorod produced by the method of claim 1 has the perfect orientation. *Id.* The

Choy Declaration also reviews Fig. 1C of Tian and notes that the ZnO nanorod prepared by the method disclosed in Tian is imperfectly oriented and has a helical structure. *Id.* Then, the Choy Declaration concludes that producing the perfectly oriented ZnO nanorods according to the method of claim 1 would have been unexpected given the disclosure of Tian that the nutrient solution containing HMT, Zn nitrate and sodium citrate only produced imperfectly oriented ZnO nanorods and lack of any guidance in Tian regarding how to produce perfectly oriented ZnO nanorods. *Id.*

Applicants respectfully submit that the Choy Declaration is submitted to comply with the Patent Office request to present the proof of factual evidence for the unexpected results. In addition, since claim 1 has been amended to recite the substrate that is made of Si, the unexpected results presented herewith is fully commensurate with the scope of the invention. Therefore, Applicants respectfully submit that the Choy Declaration concurrently submitted herewith together with the amendment of claim 1 render the Patent Office's reasoning for maintaining the current obviousness rejection. Reconsideration and withdrawal of this rejection are respectfully requested.

II. The Patent Office has rejected claims 1, 4 and 6 under 35 U.S.C. §103(a) as obvious over Boyle. The Patent Office asserts that even though Boyle discloses that "HCl is added dropwise (experimental section), with HCl added is in negligible amount, or being part of the solvent, the nutrient solution Boyle et al. still reads on claims 1 and 10." Applicants respectfully disagree.

With respect to the absence of HCl in the nutrient solution recited in claim 1,

as explained above, Boyle itself acknowledges that it is essential to impend twinning of ZnO crystallites and to enhance the crystallinity and growth of ZnO rods. Boyle thus provides no suggestion or motivation for one skilled in the art not to use chloride ions with a reasonable expectation of success of obtaining the equivalent results. Nonetheless, as explained above, the claimed method provides superior and unexpected results in growing perfectly oriented ZnO nanorods without using chloride ions. Therefore, the omission of the chloride ion from the nutrient solution of claim 1 itself is sufficient to find claim 1 patentable over Bolye. Moreover, Applicants respectfully submit that the unexpected and superior results of claim 1 as demonstrated in the Choy Declaration effectively rebut any inference of obviousness of claim 1.

III. Claim 10 has been rejected under 35 U.S.C. §103(a) as obvious over Boyle in view of Tian. The Patent Office contends that since zinc acetate and zinc nitrate are functional equivalents in terms of being a zinc source in the process of making ZnO nanorod arrays, substituting the zinc acetate of Boyle with the zinc nitrate of Tian is *prima facie* obvious. Applicants respectfully traverse this rejection. Claim 10 is dependent upon claim 1 and recites the nutrient solution consisting of HMT, Zn nitrate and a solvent. Applicants specifically incorporate herein the argument regarding Bolye set forth above. In addition, Tian does not cure the deficiency of Boyle because it does not teach or suggest that chloride ions are non-essential to grow ZnO nanorods without twinning. Thus, the combined teaching of Boyle and Tian fails to establish a *prima facie* case of obviousness of claim 10. Furthermore, any inference of obviousness of claim 10 is effectively rebutted by the unexpected

and superior results achieved by the method of claim 1. Therefore, reconsideration and withdrawal of the rejection of claim 10 are also respectfully requested.

Claims 2, 5, 7 and 13 remain rejected under 35 U.S.C. §103(a) as allegedly obvious over Tian, in view of Boyle and Ren. The Patent Office alleges that while Tian does not specifically teach that the method would be used to synthesize a nanowall array, Ren teaches methods to synthesize ZnO of varied nanostructure morphologies on a substrate like nanowalls and nanorods. Then, the Patent Office takes a position that nanowalls and nanorods are obvious variances absent evidence to the contrary. The Patent Office alleges that "one of ordinary skill in the art would have appreciated either form of ZnO nanostructure base on industrial needs and applicability." With respect to the amended feature of "consisting of," the Patent Office again alleges that even though the nutrient solution of Tian further comprises HMT, eliminating a non-essential element is *prima facie* obvious. Applicants respectfully disagree.

As noted in the Choy Declaration and acknowledged by the Patent Office, the nutrient solution recited in claim 2 does not contain HMT even though both Tian and Bolye use HMT in their nutrient solutions. Regarding this difference, the Patent Office takes the same position as with sodium citrate and chloride ions, arguing that HMP is a non-essential element and eliminating the non-essential element is *prima facie* obvious. However, the Patent Office has failed to provide any factual evidence supporting its assertion that HMP is a non-essential element to prepare ZnO nanostructures. Contrary to the Patent Office's allegation, however, HMP is an essential component for preparing ZnO nanostructures by providing a role of supplying OH^- ion in combination with Zn^{2+} to form ZnO as follows:

$(CH_2)6N_4 + 6H_2O \leftrightarrow 6HCHO + 4NH_3$ (7)
$NH_3 + H_2O \leftrightarrow NH^{+4} + OH^-$ (8)
$2OH^- + Zn^{2+} \rightarrow ZnO(s) + H_2O$ (9)

The Choy Declaration at Section 10 (citing Topical Review, *Sci. Technol. Adv. Mater.* 10 013001, p. 7 (2009))[1].

With this in mind, the Choy Declaration concluded that HMP is critical or essential component to grow ZnO nanoparticles. *Id.* The Choy Declaration opined that growing ZnO nanoparticles using the nutrient solution without containing HMT would have been unexpected to one skilled in the art. *Id.*

Furthermore, according to the Choy Declaration, the nanowall array of claim 2 is different from the nanostructures disclosed in Ren in its crystal structure. More particularly, the Choy Declaration notes that the nanowall arrays prepared by the method of claim 2 show UV laser threshold of 5 kw/cm, which is about 90% lower than the lowest threshold obtained in currently available nanorod arrays. *See* the Choy Declaration, at Section 11. According to the Choy Declaration, this unexpected result is based on the extraordinary crystal structure in which the c-plane of ZnO nanowalls lies perpendicular to the substrate. *Id.* The Choy Declaration explains that with this perpendicular orientation, ZnO nanowalls can work as an optical wavegide and also a trapping agent. *Id.* However, as set forth in the Choy Declaration, the nanostructures developed by Ren has the c-plane of ZnO crystal parallel with the substrate as shown in Fig. 17A of Ren. *Id.* Although the external appearance looks similar between the ZnO nanowalls produced by claim 2 and the ZnO nanostructures disclosed in Ren, the crystal structures that are essential part in optical applications are totally different in each other. These different crystal

[1] While Topical Review was published in 2009, the references cited therein to show the role of HMT were published prior to the effective filing date of the present application.

structures are unexpected results to one of ordinary skilled in the arts based on the disclosure of the prior arts and thus the two structures cannot be considered as an obvious variance. Accordingly, Applicants respectfully submit that Tian either alone or in combination with Bolye and Ren, cannot render claim 2 obvious. Reconsideration and withdrawal of this rejection are respectfully requested.

In light of the foregoing, Applicants submit that all outstanding rejections have been overcome, and the instant application is in condition for allowance. Thus, Applicants respectfully request early allowance of the instant application. The Commissioner is hereby authorized to charge any fees or credit any overpayment to Deposit Account No. 02-2135.

Date: June 1, 2010 By: _____

Joseph A. Hynds
Registration No. 34,627
ROTHWELL, FIGG, ERNST
& MANBECK, P.C.
1425 K Street, N.W., Suite 800
Washington, D.C. 20005
Telephone: (202)783-6040
jhynds@rfem.com
Attorney for Applicants

JAH/JMK/jpf
1737212_1